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The user-value of rural electrification: An analysis and adoption of existing models and theories

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ABSTRACT

User-value is a determining factor for product acceptance in product design. Research on rural electrification to date, however, does not draw sufficient attention to the importance of user-value with regard to the overall success of a project. This is evident from the analysis of project reports and applicable indicators from agencies active in the sector. Learning from the design, psychology and sociology literatures, it is important that rural electrification projects incorporate the value perception of the end-user and extend their success beyond the commonly used criteria of financial value, the appropriateness of the technology, capacity building and technology uptake. Creating value for the end-user is particularly important for project acceptance and the sustainability of a scheme once it has been handed over to the local community. In this research paper, existing theories and models of value-theory are transposed and applied to community operated rural electrification schemes and a user-value framework is developed. Furthermore, the importance of value to the end-user is clarified. Current literature on product design reveals that user-value has different properties, many of which are applicable to rural electrification. Five value pillars and their sub-categories important for the users of rural electrification projects are identified, namely: functional; social significance; epistemic; emotional; and cultural values. These pillars provide the main structure for the conceptual framework developed in this research paper. It is proposed that by targeting the values of the end-user, the key factors of user-value applicable to rural electrification projects will be identified and the sustainability of the project will be better ensured.

Contents

1. Introduction

This research paper seeks to develop a conceptual framework by applying value-theory to rural electrification. This framework

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Table 1
Summary list of barriers to the successful implementation of rural electrification projects.

Challenges
Financial: High upfront cost requiring savings over time; unavailability of capital; and lack of initiative through dependency on subsidies [6–11]
Infrastructure: Access to market through lack of local infrastructure and other market-based factors (e.g. competition, and marketing) [6,12–15]
Technical: Low technical skill levels and access to quality materials/products [12,14–16]
Social: Local ownership and acceptance [8,17–25]

begins to answer the question: "What are the prevailing value characteristics for rural villagers when implementing rural electrification projects?"

Rural electrification[1] is seen as a key mechanism to: improve living standards [1]; increase income through 'income generating activities' [2]; and improve community services such as education and healthcare [3]. However, to date, mechanisms to implement rural electrification projects are far from perfect as problems with dissemination and sustainability in rural areas have not abated [4,5]. As Lahimer et al. puts it "*rural electrification is a complicated issue because of user affordability*, *rural inaccessibility and remoteness*, *low population densities and dispersed households*, *low project profitability*, *fiscal deficit*, *scarcity of energy resources*, *population growth*, *lack of professionalism*, *and over-dependence on subsidies*" [6]. A summary of challenges faced is shown in Table 1.

The review of literature on challenges and issues in the field of rural electrification shows that development work typically focuses on economic and physical aspects of development and often neglects the needs of the local communities that are affected by it [21,26]. A recent study undertaken by Bhattacharyya (2012) revealed that a large set of rural electrification literature focuses on techno-economic factors which are often technology and country specific [27]. This is in line with the findings of Schillebeeckx et al. (2012), who carried out a large literature review and found that the majority of research within the field of rural electrification can be categorised under the following five headings: country-based approach; local potential; technology policy; institutional issues; and drivers of success. The latter is limited to a small number of case study sites [28]. Despite this focus there is clear evidence of the importance of 'project ownership' as a key driver for project sustainability of community-operated rural electrification schemes (the main focus of this research paper) once the scheme has been handed over to the community [17,18]. This is highlighted by the following statements: "…*ownership of development initiatives as a means to sustainable community development*" [19]; "*true participation* […] *ensures people take ownership*" [20]; and "*infrastructure is maintained and repaired locally*, *based on a sense of local ownership*" [21]. This is further emphasised in research by [8,22–25]. According to these authors, factors that influence responsible ownership include community involvement, user training, and contributions in kind (material or labour). For a more comprehensive list refer to Table 2.

According to Wilson et al. (2012, p.12), "it is generally agreed that a sense of ownership is an indicator of success (albeit one that can be hard to measure), [although] there is less consensus over other considerations that might be interpreted as evidence of 'success', depending on one's perspective" [22]. This suggests that academia and the development sector could improve upon the investigation of factors influencing the success of rural electrification projects. For example, parallels could be drawn with the success indicators regularly described in product design, whereby product demand and the end-user's perception of personal product value influences the product's success [35]. Nurkka et al. (2009, p.451) expressed that, "…individual values have a significant impact on consumers' inclinations to adopt new products" [36]. The rural electrification analogy would investigate the success of a project/scheme based on its value,[2] as perceived by the user(s) from a personal perspective. Inclusion of the needs and priorities of end-users is seen as a key factor in the sustainable design of infrastructure projects [37,38]. This will help to improve understanding of the complex interaction between the user of the service and the service itself – a topic much neglected in current literature on infrastructure development [39].

Table 2
Summary of factors influencing local ownership responsibilities of rural electrification projects.

Factors influencing local ownership
Training users and local technicians [29–31]
Financial contributions [17,32,33]
Contribution in kind (labour & materials) [17,18,24,31]
Local participation during the project stages [17,23,24,34]

Further to this, in some countries the rural electrification sector is gradually becoming more commercial as governmental donors embrace commercial approaches, causing a shift away from the traditional 'donor to recipient' model, and towards a market-based model. This is exemplified in projects such as the: Private Sector Participation Programme (PSPP) in Rwanda [40]; AR PERMER Renewable Energy Additional Financing Project in Argentina [41]; Energy Development and Access Project in Ghana [42]; and Rural Electrification Senegal (ERSEN) [43]. The latter of which does not directly support the private sector but strengthens governments, better enabling future private sector involvements. However, despite this move towards a market-based model, the sector continues to be dominated by donor approaches and has yet to shift to a more commercial approach, whereby existing business concepts are transposed and applied to development work. In product design, for example, the importance of user-value on the overall product success has long been acknowledged [44] from as early as the 1990s [45]. Creating user-value by broadening the perception of a 'product experience' rather than just 'object-interaction' is seen as the predominant factor for product success [46]. This has also been acknowledged in the development of energy products for emerging economies (such as solar lanterns or biomass stoves), and is highlighted in many reports [47–49]. Hence, the aim of this research paper is to identify properties that are important for shaping the uptake and success of rural electrification projects in developing economies by considering different value types applicable to electrification as a service.

This paper is separated into three sections: firstly, existing value models and tools are outlined; secondly, the value properties

[1] In this research paper rural electrification includes decentralised schemes that provide electricity to remote rural areas, including small-scale hydropower plants, generators, and solar panels (with a specific focus on community operated projects). Products or decentralised schemes are excluded.

[2] In this research human value is referred to as: "*desirable, trans-situational goals, varying in importance that serve as guiding principles in the life of a person or other social entity*" [35].

applicable to rural electrification are discussed; and finally, the paper concludes with a conceptual framework for the value perception of end-users when implementing rural electrification in decentralised community-operated schemes.

2. Overview of models and tools of sociological value and definition of value

Understanding the perceived value (what is important) to the individual customer (in the case of rural electrification these are often referred to as the beneficiaries) as well as to the community as a whole is important in order to appreciate their real motivations and the drivers for ensuring the sustainability of a scheme. This is in line with Woo (1992) who states "[*value is*] *what is of true worth to people in the broad context of the well-being and survival of individuals*, *and by extension*, *of the species as a whole*" [50]. Motivations may include, for example, the flexibility of the power output, the novelty of the project and the sense of safety the scheme provides through street lighting. However, as highlighted by Zeithaml [51], Woodruff [52], and Holbrook [53], the degree of value differs between objects, individuals or groups and circumstances (time, location and environment). For rural electrification, the service provided (electricity) remains the same but the extent to which the service is valued and the way in which it is delivered can be different. A few examples (non-exhaustive list) of potential variables adjusted to suit different schemes are as follows: the power availability per household; the flexibility of supply; and the intended use of the electricity. Consequently, the perceived value differs. Value is a broadly used term, and all of the theories are unique in their approach towards analysing user-value [54]. However, concepts of sociological value most often refer to the cultural, social and individual behaviour of people within communities [55]. According to Woodall [56], who assessed 90 different value studies, there are three commonalities describing the perceived value. Value is: (i) inherent in or linked to the use of the product, service or object; (ii) something perceived by customers rather than objectively determined, and; (iii) a trade-off between what the consumer receives and what he or she gives up to acquire and use a product or service [56]. As Boztepe [44] has pointed out, by focusing on the experience of a product or service, there is a potential to incorporate the different approaches discussed above [44]. Discussed below are four major value theories applicable to this research: value in exchange; value in use; value in experience; and value in sign.

(1) **Value in exchange** – Within the economic paradigm, a product or service has a certain value to individuals. This theory assumes that customers make a decision to purchase at the point of product exchange. This is in line with Philip Kotler's theory and refers to trading one form of value, usually monetary, for another form of value [57]. This shows their willingness to pay (WTP) an agreed amount for a product or service [10,51,58]. In rural electrification, the WTP can be tested through auctions, for example [59,60]. While this theory is more applicable to products, it is however, relevant for rural electrification schemes, as communities are often expected to commit to the scheme through labour or in kind before implementation. This is illustrated in the following project reports by ESDA and GIZ [61,62].

(2) **Value in use** – The 'value in use' theory refers to the value perceived by customers when using a product or service [52]. This relates more to the user's practical experience when interacting with their purchase. In rural electrification, value is predominantly created through the service experience (known as subjectivism[3] [53]), see below. This is particularly true for remote areas and countries with extremely low electrification rates (e.g. Sub-Saharan Africa (SSA)). Nevertheless, customers may still hold a certain level of expectation for electrification created by the increase in mobile phone usage and the need for mobile phone charging facilities,[4] for example

(3) **Value in experience** – The importance of experience is highlighted by Pine and Gilmore [63] and Holbrook [53]. They believe that the consumer desires a product or service for the associated emotive experience/interaction, and not necessarily for practical reasons. This is, however, user-subjective. Experience can be active or passive (known as 'trying' and 'undergoing' respectively) (as seen in [53,64]). In rural electrification for example, it is the provision of electric lighting that leads to less eyestrain because of increased and consistent (no flickering) lumen output in the surrounding atmosphere. Eyestrain is commonly associated with the usage of kerosene lanterns (the common form of lighting in rural areas) [65,66].

(4) **Value in sign** – This is a complementary value strand proposed by the sociologist Baudrillard [67]. The sign value refers to the prestige (social status) of the product or the service rather than the value of the actual object, its function, or the user value derived from it [67]. Having an electric light, for example, can signify a higher social status within the community. A recent study has shown that one of the perceived benefits from electricity in rural villages is the improved social status [68]. This is in line with Veblen (1953) who highlights that goods may be valued because of the prestige that comes with them [69]. For example, in emerging economies people may strive for a product or service because it resembles the lifestyle of the Western World [70]. Additionally, as many of the rural population may desire an urban lifestyle, rural electrification may initiate countryside urbanisation or 'urban living'. This desire for 'urban living' is believed to originate from its association with improved development and opportunity. Rapid urbanisation trends in developing countries may also be a necessity to generate income in rural areas [71].

In addition to the four value types described above, rural electrification can be classified as an *extrinsic value* (also known as instrumental value or contributory value), as it leads to the accomplishment of further outputs and is not an end in itself (*intrinsic value)* when seen from an end-user perspective [53]. This is important as the benefit from rural-electrification schemes goes beyond power output, and can lead to long-term positive development when designed properly. However, when considering the user-value of rural electrification projects it is important to consider the value to all stakeholders. For the operator, for example, electricity can have intrinsic value because his role does not involve the further benefits which end-users can enjoy; that is, the interaction with appliances powered by the electricity he oversees the generation of. Additionally, stakeholder value includes that of individual beneficiaries as well as the entire community, project implementation team, and governmental organisations. In value theory, these are referred to as *self-oriented values* (individual) and *other-oriented values* (everyone else) [56]. The latter can be broken down into a *micro* level (e.g. family and friends), *intermediate* level (e.g. the community) and *macro* level (e.g. nature) [53,64]. Additionally, it is important to note that users are often willing to trade less of one value for more

[3] Subjectivism, according to the OED refers to, "the practice of giving priority to or laying emphasis on subjective consciousness, personal experience…" [116].

[4] Mobile phone usage increased by 49% yearly in SSA from 2002 to 2007, even reaching highly remote areas [117]. This leads to greater awareness about the need for electrification and its understanding.

of another value (trading off less salient for more salient values) [72]. Based on the above, value properties applicable to the service of providing electricity are discussed below.

3. Value properties pertaining to electrification as a service

There are a variety of different conceptual frameworks available in the literature. However, no framework applicable to rural electrification was found in this literature review. Consequently, in order to develop a framework for rural electrification, in addition to the work discussed above, the two comprehensive frameworks developed by Boztepe [44] and Smith [73] provided the baseline. Both made use of the wider literature on user-value (value-theory). A summary of the 51 value-aspects identified is shown in Table 3 in Appendix. Characteristics could then be clustered in the following five pillars: functional, social significance, epistemic, emotional, and cultural values. Fig. 1 summarises

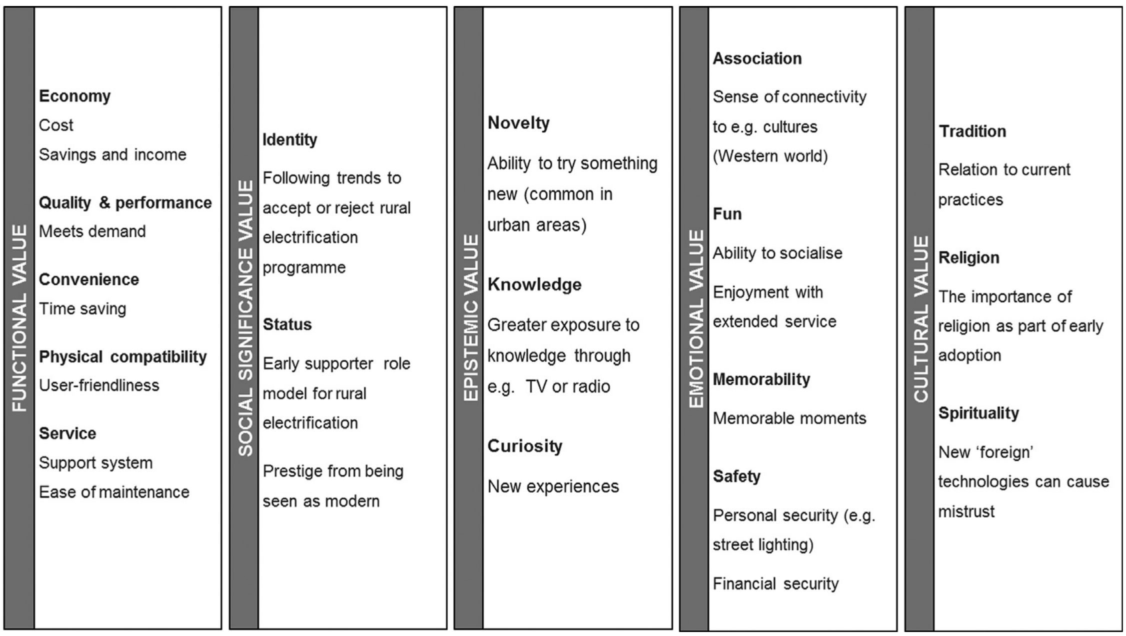


Fig. 1. Five pillars of user-value applied to rural electrification, including sub-categories.

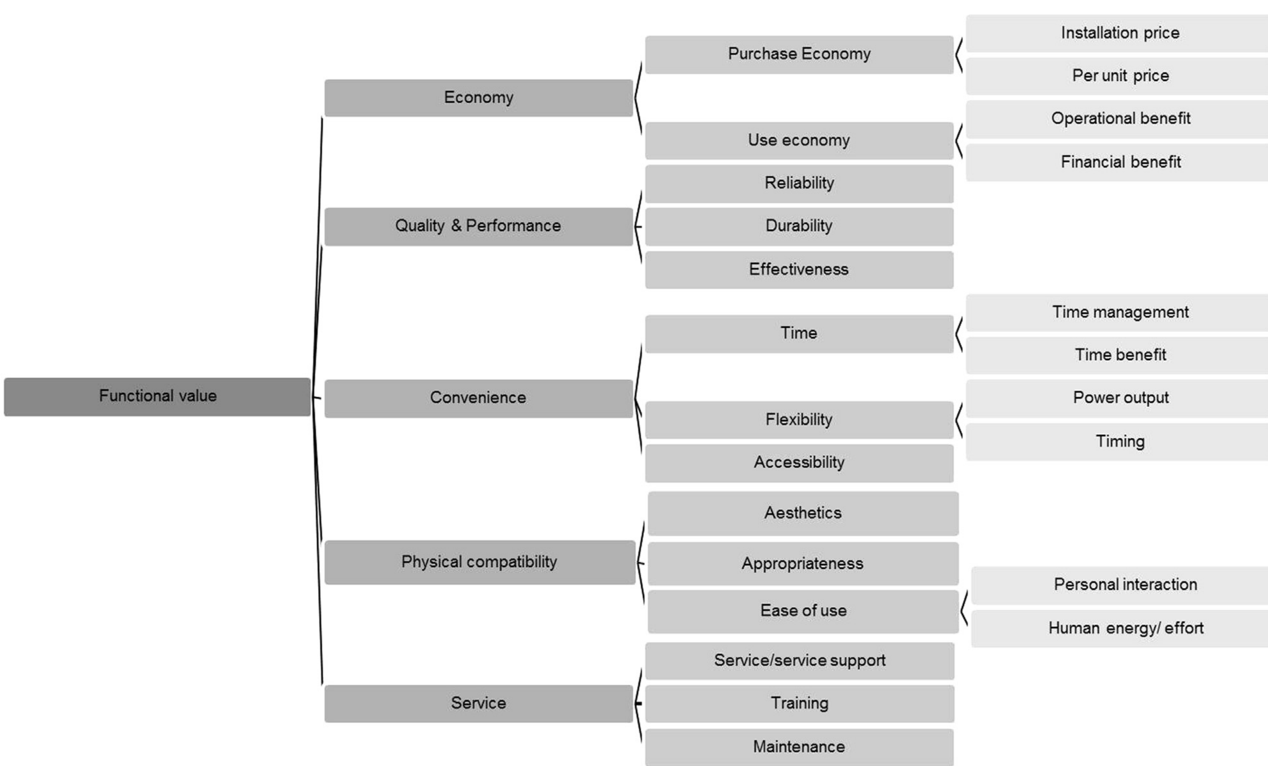


Fig. 2. Hierarchical structure of functional value.

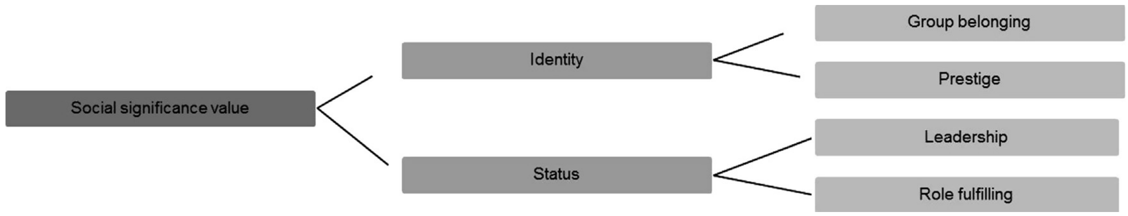


Fig. 3. Hierarchical structure of social significance value.

the value pillars and their respective attributes with respect to community-operated rural electrification; these are discussed further in the following sections.

3.1. Functional value

In line with Drucker the functional value is concerned with "*customers pay*[ing] *only for what is of use to them and gives them value*" [74] and covers the main function of the product or service including utilitarian and physical attributes [72]. In the words of Broekhuizen, this can be understood as the "*utility derived from the product quality and product performance*" [75]. The *utility* is the price and the quality, coined as the 'worth' [56]. This corresponds to the *utility* definition given by OED "*the fact, character, or quality of being useful or serviceable; fitness for some desirable purpose or valuable end; usefulness, serviceableness*" [76]. In line with the utility value framework developed by Boztepe, the functional value applicable to rural electrification covers the following five value streams [44]: economy (financial benefits [56]); quality and performance (reliability and flexibility [77]); convenience (operational benefits [56]); physical compatibility; and service (Fig. 2).

In rural electrification, the ***economy value*** is two-fold: purchase economy and use economy. The **purchase economy** refers to (a) the physical cost of the installation (upfront cost) and (b) the per unit price (cost per kWh of electricity used). According to the literature, upfront cost is a major barrier for the widespread diffusion of rural electrification technologies [78–80]. Consequently, product/project developers design solutions that resemble current spending patterns for kerosene or candles, e.g. pay-as-you go or fixed monthly cost. This is exemplified in the following developments: micro-finance with Germeen Shaki [81]; pay-as-you-go with M-KOPA [82]; and rental franchise with Sunlabob [83]. The **use economy**, on the other hand, relates to the actual *financial benefits* gained through the project. This can be (a) monthly saving through the replacement of traditional energy sources or generators [78,84] and (b) a rise in income from the potential increased portfolio of income generating activities such as grain processing [85]. However a reduction in the energy bill is not always the norm as consumption may increase because of additional energy expenditures from television or refrigeration [86]. Further to this, whilst the authors believe that income generating activities are essential for poverty eradication, the utilisation of income generating activities remains low at present [87].

Reliability, *durability*, and *effectiveness* can be categorised under ***quality and performance***. The *reliability* refers to the consistency of supply. Brownouts[5] and blackouts are very common in developing countries, as supply cannot meet demand [88,89]. Consequently, organisations deploy load-shedding strategies to avoid unexpected shortfalls in power. Load-shedding is more common in larger electrification projects, as can be seen in Bangladesh [90] and Uganda [91]. However, there are also cases in which load-shedding is used on smaller-scale hydropower projects, whereby mechanisms are installed to allow for battery charging during the day (to generate income to cover operation and maintenance cost of the scheme) and lighting at night [92]. *Durability* is concerned with the longevity of the equipment (such as hydropower turbine) as well as the electrical components (e.g. house installation). The *effectiveness* can be seen as the extent to which the power supplied meets the demand of the specific community. Some individuals in a community for example, may be only interested in lighting and consequently, solar lanterns maybe the best solution for them in the short-term. Despite there being multiple applications using electricity, to date "lighting" is seen as the most desired application by rural communities [86]. This could be because of project developers promote electric lighting above alternative applications. This suggestion is supported by a recent study which found that, "*… the benefits derived from electricity, include perceived improved security, better quality lighting, entertainment, and a sense of inclusion through television and through the social prestige of coming from a village with electricity. With exception of lighting and to a lesser extent, security, these are not the benefits that developers normally advance when targeting communities with electricity*" [68].

Convenience applies to the following three branches: *time*, *flexibility*, and *accessibility*. For rural electrification the *time* value has two main components: (1) the time saved by the replacement of traditional fuels (time benefits) and (2) the planning required when using electricity (time management). Time benefits occur when (a) time consuming activities such as the collection of firewood are eliminated [2] or (b) processes are speeded up because of the higher energy content of the replacement fuel (e.g. grinding). Time management, on the other hand, is necessary to plan for specific activities such as load shedding (described above). *Flexibility* refers to the ability to adjust the time as well as the energy supply to meet the changing needs of the beneficiaries over time. As discussed above, consumption may increase with time because of increased desires such as TV or refrigerators [86]. The IEA has recognised that energy levels are dynamic. Once an initial connection has been made, energy consumption increases to the regional average within 5 years [93]. For rural electrification the *accessibility* can refer to the technology itself or to the ability to access suitable equipment or appliances, with the latter being more crucial to the success of the scheme [94,95]. However, the accessibility to electric appliances remains low with only 20% of the poor people globally able to benefit [1].

The ***physical compatibility*** has three characteristics, namely: *aesthetics*, *appropriateness*, and *ease of use*. The *aesthetics* of the alternative method (e.g. replace kerosene lanterns with light bulbs) may be measured upon comparison with the traditional. This is particularly true for the quality of the light produced (e.g. kerosene lamps produce 'warm' light and LEDs give a 'cold' light). A field study in Uganda showed, for example, that rural customers made pico-PV purchasing decisions based on their perceptions associated with the light output of the lantern [60]. The appropriateness of the service relates to the extent to which the availability of electricity meets the specific needs of a community. A community, for example, that relies on metal processing for income generation may require a larger power output than a community that relies on agriculture. The *ease of use* is concerned

[5] Brownouts refer to a drop in voltage in a power system [118].

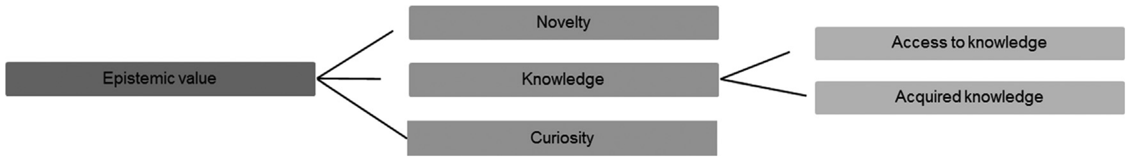


Fig. 4. Hierarchical structure of epistemic value.



Fig. 5. Hierarchical structure of emotional value.

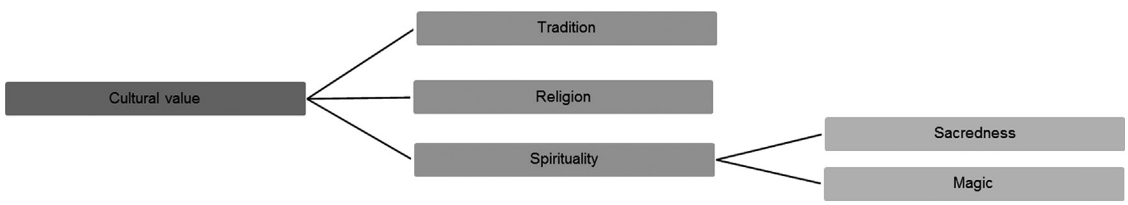


Fig. 6. Hierarchical structure of cultural value.

with the ability of the end-user to operate the new technology with little guidance or training. This is important as the operation of new technology and associated equipment may be challenging if it is over-complex or unintuitive [96]. It is hence paramount to utilise appropriate technologies and/or to provide end-user training, as shown in the following examples [61,97].

Although, the three ***service*** branches of *support*, *training* and *maintenance* can be covered within the existing value pillars as seen in [56,73,98], they are here considered within an independent entity, namely: *service*. This is because, as noted above, they are a major influencing factor on the success of rural electrification schemes.

3.2. Social significance value

Social significance value (also referred to as identity value) relates to different social groups (in terms of status and identity) [44,72] as well as the sensorial nature of the product or service (referring to the perceived feeling) [73]. The social significance value has two main components: identity and status (Fig. 3).

According to Holbrook "value resides not in the product purchased, not in the brand chosen, not in the object possessed, but rather in the consumption experience(s) derived therefrom" [53]. However, Holbrook's statement (based on his 'value-as-user-experience' theory) fails to acknowledge the importance of identity and status. For the purpose of this research the identify value refers to a person's association with a group and covers the two characteristics: group belonging, and prestige. For group belonging, for example, a person may accept a rural electrification project because of 'conspicuous consumption'[6] rather than need. This has also been evident during the distribution of energy efficient biomass stoves in Sri Lanka [99]. A study, undertaken by the Shell Foundation, found that the uptake of improved cooking stoves increased because consumers followed their neighbours' trends [100]. In addition to the prestige described above (Section 2, point 4 'value in sign'), prestige may refer to a person's early acceptance (early adopter) of the rural electrification scheme because of their need to distinguish themself from the group. Both, the need for esteem and belongingness, are, according to 'Maslow's Theory of human motivation', key drivers for human development [101]. Status refers to the individual role and the impact of an individual on the wider group and covers role fulfilment and leadership. For example, a village chairman's support for rural electrification may influence a community's decision (leadership) and his role as a leader (status) therefore could have an influence on the overall project acceptance [102,103].

3.3. Epistemic value

Epistemic value is a branch of epistemology and refers to the '*method or grounds of knowledge*' [76] and has the following characteristics: (a) to satisfy a desire for knowledge; (b) to provoke curiosity; and (c) to provide novelty [72]. As shown in Fig. 4.

According to Sheth et al. (1991), "*entirely new experiences certainly provide epistemic value… a change of pace can also imbue epistemic value*" [72]. Rural electrification is in line with this sentiment as it aims to provide electricity to remote areas. Electrification schemes in rural remote areas can be seen as a novelty to replace traditional fuels and consequently people may strive for it. This is exemplified in a Solar-Home System (SHS) project in Peru, "*the installation of Prodia's experience in Peru showed that at first only a few families put themselves forward for a SHS as others were unsure of the technology. After installation, the sceptics' curiosity was satisfied and many more families wanted to participate*" [88]. Electrification *requires knowledge* to: (a) operate and maintain a scheme and (b) enable full utilisation [88,104]. However, such schemes also enable the new *acquisition of knowledge*. This may be owing to: increased awareness from access to TV and radio; extended access to education (schools are able to extend opening hours into the evening as a result of electric

[6] A term coined by the sociologist and economist Thorstein Veble, referring to people that benchmark their standards of living against their peers [119].

lighting); and exposure to standards of living associated with different cultures (users may relate electricity consuming activities to urban or 'western' demographics), which may also arouse curiosity.

3.4. Emotional value

The emotional value refers to non-cognitive and unconscious decisions that are made based on for example, childhood experiences [72]. From the literature and the applicability to rural electrification, there are four main characteristics that can be linked to emotional value. These are: association, fun, memorability, and safety (Fig. 5).

For rural electrification, **association** may refer to one's sense of connectivity towards a different class, culture, or people that use electricity. For example in Kenya people felt a desire for Western lifestyle and longed for a light switch and a permanent bulb in their home [60]. **Fun** can be two-fold, seen as: (a) fun with the family (or on your own), watching TV, listening to music or fun with 'new' equipment (object), light switches or TVs and (b) fun through the ability to socialise with peers into the late evening hours, for example. This in turn may lead to **memorable** moments. Additionally, electricity may provide a sense of **security** through improved lighting and lower risk of fuel shortage. The first of which is perceived to be one of the key benefits of rural electrification by developers [68,105,106]. Additionally, as outlined by Yadoo "*by generating energy from indigenous power sources, renewable energy power technologies can protect against fluctuations in international fuel prices, improving energy security and local resilience*" [107].

3.5. Cultural value

According to OED (2013) culture can be defined as "*the distinctive ideas, customs, social behaviour, products, or way of life of a particular nation, society, people, or period*" [76]. In line with this the cultural value applicable to rural electrification covers the following three value streams: tradition, religion and spirituality (Fig. 6).

Tradition refers to the transmission of statements, beliefs, rules, and customs that are carried forward from the past but are still followed in current culture [76]. Rural electrification is considered to fulfil the requirement for development intervention through, for example, improved health and education [108]. However, while the technology may act as an enabler of better health and education, tradition may be a barrier to its successful adoption as villagers continue to cook using firewood and children continue to collect the firewood [109]. **Religion** is, according to Solomon's evaluation of a wide range of literature on consumer behaviour, a determining factor of buying behaviour in consumers [110]. While religious convictions are declining in the developed world, religious beliefs remain high in the developing world [111,112]. A set of religious beliefs may govern: the role of women in society; the role of technology or technological advancement in society; and locations of spiritual significance. This can affect decisions regarding the siting, modes, purpose of, and location of

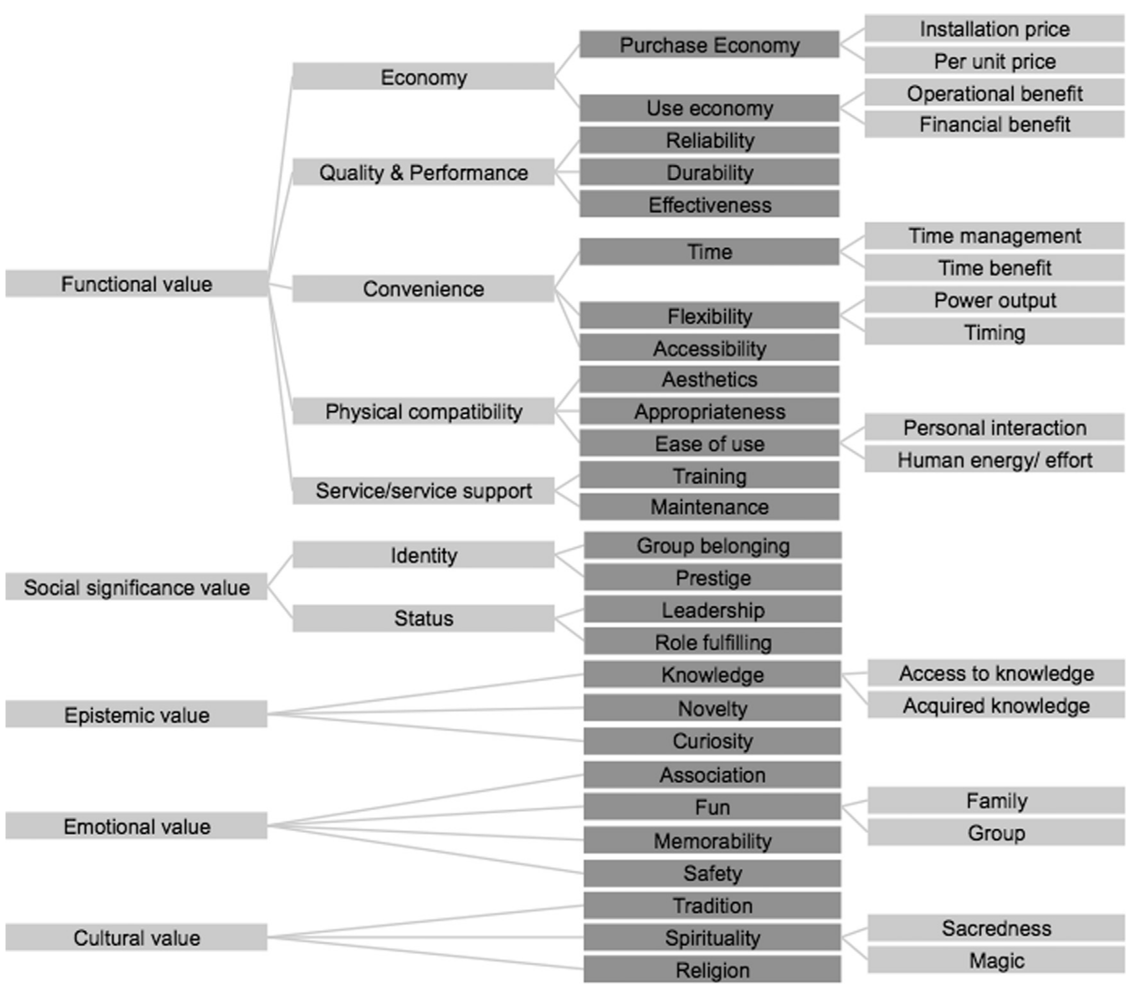


Fig. 7. Value framework rural electrification.

electrification schemes. **Spirituality** can refer to material things or substances in a figurative or symbolic sense [56,113,114]. In rural electrification this may be significant when implementing hydropower schemes. For the Bujagali hydropower project in Uganda, for example, spirits living in the waterfall had to be relocated to allow for the scheme to be built. This required a ceremony to avoid upsetting the spirit [115]. On the other hand, people may be scared of 'foreign' technologies (Fig. 7).

4. Conclusion

The aim of this paper is to develop a holistic value-framework with factors that generate value for the community when implementing community-operated rural electrification projects in the developing world. Understanding the user perceived value is important because: (a) mechanisms to implement rural electrification projects are far from perfect as problems with dissemination and sustainability in rural areas have not abated and (b) rural electrification is gradually becoming more commercial as the sector moves towards a market-based approach. To develop this framework, value-theory (a common approach in marketing and business) has been applied to rural electrification. The holistic nature of value-theory in conjunction with rural electrification allows for a wide range of issues to be covered, which have not yet been explored in the rural electrification literature. The following five value pillars, important for the success of rural electrification schemes, have been identified: functional; social significance, epistemic; emotional; and cultural values. The success of rural electrification schemes may be influenced by any of the pillars and their applicable characteristics. Consequently, using value-theory provides a meaningful and holistic way of giving guidance and measuring the success of rural electrification projects.

The review of the literature showed that, to date, project considerations are mainly based on the assessment of techno-economical factors; such as the purchase/use of a scheme. Rarely are socio-cultural factors taken into consideration. These may, however, reflect more accurately the needs and desires of a community and subsequently generate user value. For example, the acceptance of a scheme may depend on its ability to promote village status. Further to this, to ensure community commitment, it is paramount to generate value for the entire community, i.e. meeting needs and the desires of the different benefiting stakeholder groups. An individual, for example, may have different needs and desires than the community as a whole. Furthermore, for the beneficiaries power provision should not be seen as a means to an end, instead it should be seen as an opportunity for growth to effectively contribute to rural development.

The holistic value-framework developed in this paper provides the basis to begin answering the questions: what are the prevailing value characteristics for rural villagers, and why are some more important than others? Once tested in the field, this framework will: (a) contribute to the understanding of consumer value in a rural electrification context and (b) assist practitioners, policy makers and organisations in determining what motivates communities to ensure the longevity of development projects.

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Table 3
Attribute comparison existing framework's by Boztepe [44,46] and Smith et al. [73].

User-value aspects	Boztepe [44,46]	Smith et al. [73]
Accessibility	×	
Aesthetics		×
Affection	×	×
Appropriateness	×	
Association		×
Avoidance of sensory unpleasantness	×	
Cognitive difficulty/ stress		×
Conflict		×
Convenience	×	×
Curiosity		×
Customization		
Delivery and installation		×
Durability	×	
Effectiveness		×
Efficiency	×	×
Emotional	×	
Equity		×
Ethics		×
Face saving acts	×	
Flexibility		×
Fun/play/enjoyment/pleasure	×	×
Good luck	×	
Group belongingness	×	
Human energy/effort		×
Impression management	×	
Knowledge		×
Learning cost		×
Maintaining tradition	×	
Memorability	×	
Network benefits		×
Novelty		×
Operating cost		×
Operational benefit		×
Performance	×	×
Personal interaction/ease of use		×
Physical compatibility	×	
Process cost		×
Purchase economy/price/direct cost	×	×
Quality	×	×
Relational benefits		×
Relational/relationship cost		×
Reliability	×	×
Role fulfilling	×	
Safety/security	×	×
Search cost		×
Service/service support		×
Spirituality	×	×
Status/esteem/image/prestige	×	×
Time/time management	×	×
Training and maintenance		×
Use Economy/inancial benefit	×	×

Appendix

See Table 3.

References

[1] Practical Action. Poor people's energy outlook. Rugby, UK: Practical Action Publishing; 2010.
[2] Practical Action. Poor people's energy outlook: energy for earning a living. Rugby, UK: Practical Action Publishing; 2012.
[3] Practical Action. Poor people's energy outlook: energy for community services. Rugby, UK: Practical Action Publishing; 2013.
[4] Williams AA, Simpson R. Pico hydro – reducing technical risks for rural electrification. Renew Energy 2009;34:1986–91.
[5] Peters J, Harsdorff M, Ziegler F. Rural electrification: accelerating impacts with complementary services. Energy Sustain Dev 2009;13:38–42.

[6] Lahimer AA, Alghoul MA, Sopian K, Amin N, Asim N, Fadhel MI. Research and development aspects of pico-hydro power. Renew Sustain Energy Rev 2012;16:5861–78.
[7] Loka P, Moola S, Polsani K, Reddy S, Fulton S, Skumanich A. A case study for micro-grid PV: lessons learned from a rural electrification project in India. Prog Photovolt Res Appl 2013, http://dx.doi.org/10.1002/pip.2429.
[8] Aron J, Kayser O, Liautaud L, Nowlan A. Access to energy for the base of the pyramid. Final report. Paris: HYSTRA & ASHOKA; 2009.
[9] ESMAP. Technical and economic assessment of off-grid, mini-grid and grid electrification technologies. Technical Report; 2010.
[10] Narula K, Nagai Y, Pachauri S. The role of Decentralized Distributed Generation in achieving universal rural electrification in South Asia by 2030. Energy Policy 2012;47:345–57.
[11] Friebe CA, Flotow P, von, Täube FA. Exploring the link between products and services in low-income markets—evidence from solar home systems. Energy Policy 2013;52:760–9.
[12] Hirmer S, Cruickshank H. Making the deployment of pico-PV more sustainable along the value chain. Renew Sustain Energy Rev 2014;30:401–11.
[13] Yadoo A. Delivery models for decentralised rural electrification. Report. London (UK): IIED; 2012.
[14] Karamchandani A, Kubzansky M, Frandano P. Emerging markets, emerging models: market-based solutions to the challenges of global poverty. Cambridge, Massachusetts: Monitor Group; 2009; 144.
[15] Painuly J. Barriers to renewable energy penetration; a framework for analysis. Renew Energy 2001;24:73–89.
[16] Ashley C, Maxwell S. Rethinking rural development. Dev Policy Rev 2001; 19:395–425.
[17] Schragl P. Planning of a micro-hydropower scheme for rural electrification near Bwindi National Park, Uganda. Technical Report. Kampala: GIZ; 2008.
[18] Bhattacharyya SC. Electrification experience from Sub-Saharan Africa. In: Bhattacharyya S, editor. Rural Electrification through Decentralised Off-grid Systems in Developing Countries. London: Springer; 2013. p. 140–56.
[19] Simpson L, Wood L, Daws L. Community capacity building: starting with people not projects. Community Dev J 2003;38:277–86.
[20] Botes L, Rensburg D Van. Community participation in development: nine plagues and twelve commandments. Community Dev J 2000;35:41–58.
[21] Tango International. Sustainability of rural development projects: best practices and lessons learned by IFAD in Asia. Rome; 2009.
[22] Wilson E, Wood RG, Garside B. Sustainable energy for all? Linking poor communities to modern energy services; linking worlds series, working Paper No. 1. 2nd ed. London: International Institute for Environment and Development; 2012. p. 32.
[23] Yadoo A, Cruickshank H. The value of cooperatives in rural electrification. Energy Policy 2010;38:2941–7.
[24] Silva IP Da Vendeirinho I, Njuguna P, Njogu M. Using renewable energy in a sustainable and holistic manner as a tool to eradicate rural poverty in Africa; 2010.
[25] Benecke G. Success factors for the effective implementation of renewable energy options for rural electrification in India—potentials of the CLEAN DEVELOPMENT MECHANISM. Int J Energy Res 2008;32:1066–79.
[26] Frischmann B. Infrastructure: the social value of shared resources. New York; Oxford: Oxford University Press; 2012.
[27] Bhattacharyya SC. Review of alternative methodologies for analysing off-grid electricity supply. Renew Sustain Energy Rev 2012;16:677–94.
[28] Schillebeeckx SJD, Parikh P, Bansal R, George G. An integrated framework for rural electrification: adopting a user-centric approach to business model development. Energy Policy 2012;48:687–97.
[29] Palit D. Solar energy programs for rural electrification: experiences and lessons from South Asia. Energy Sustain Dev 2013;17:270–9.
[30] Vetter S, Pico PV. Systems in development cooperation - a focus on project sustainability. Frankfurt: Johan Wolfgang Goethe University; 2011.
[31] Drinkwaard W, Kirkels A, Romijn H. A learning-based approach to understanding success in rural electrification: insights from micro hydro projects in Bolivia. Energy Sustain Dev 2010;14:232–7.
[32] World Bank. Providing electricity to poor rural provinces in Lao PDR. IDA Work Energy; 2007.
[33] Davidson O, Sokona Y. A new sustainable energy path for African development: think bigger act faster. Senegal: Energy and Development Research Centre; 2002.
[34] Van Els RH, de Souza Vianna JN, Brasil ACP. The Brazilian experience of rural electrification in the Amazon with decentralized generation – the need to change the paradigm from electrification to development. Renew Sustain Energy Rev 2012;16:1450–61.
[35] Allen M, Ng S. The direct and indirect influences of human values on product ownership. J Econ Psychol 1999;20:5–39.
[36] Nurkka P, Kujala S, Kemppainen K. Capturing users' perceptions of valuable experience and meaning. J Eng Des 2009;20:449–65.
[37] Reed MS, Fraser EDG, Dougill AJ. An adaptive learning process for developing and applying sustainability indicators with local communities. Ecol Econ 2006;59:406–18.
[38] Fraser EDG, Dougill AJ, Mabee WE, Reed M, McAlpine P. Bottom up and top down: analysis of participatory processes for sustainability indicator identification as a pathway to community empowerment and sustainable environmental management. J Environ Manag 2006;78:114–27.
[39] Baziliana M, Welscha M, Divanb D, Elzingac D, Strbacd G, Howellse M, et al. Smart and just grids: opportunities for Sub-Saharan Africa. London (UK): Imperial College London; 2009.
[40] van der Plas R. Target market analysis: Rwanda's micro-hydro energy market. Berlin: GTZ; 2009.
[41] Johnson TM. PERMER renewable energy additional financing. Argentina: GIZ; 2008.
[42] Iyer SV. Ghana: energy development and access project. Washington (DC): World Bank; 2005.
[43] Maristes H. The Rural Electrification Senegal (ERSEN) project: electricity for over 90,000 persons. Dakar: GIZ; 2012.
[44] Boztepe S. User value: competing theories and models. Int J Des 2007; 1:55–63.
[45] Borgianni Y, Cascini G, Pucillo F, Rotini F. Supporting product design by anticipating the success chances of new value profiles. Comput Ind 2013; 64:421–35.
[46] Boztepe S. Toward a framework of product development for global markets: a user-value-based approach. Des Stud 2007;28:513–33.
[47] Schlag N, Zuzarte F. Market barriers to clean cooking fuels in Sub-Saharan Africa: a review of literature. Stockholm: Stock Environ Institute; 28.
[48] Shrimali G, Slaski X, Thurber MC, Zerriffi H. Improved stoves in India: A study of sustainable business models. Energy Policy 2011;39:7543–56.
[49] Cordes L. Igniting change: a strategy for universal adoption of clean cookstoves and fuels. Washington (DC): GACC; 2011.
[50] Woo H. Cognition, value, and price: a general theory of value. Ann Arbor: University of Michigan Press; 1992.
[51] Zeithaml V. Consumer perceptions of price, quality, and value: a means-end model and synthesis of evidence. J Mark 1988;52:2–22.
[52] Woodruff R. Customer value: the next source for competitive advantage. J Acad Mark Sci 1997;25:139–53.
[53] Holbrook MB. Consumer value: a framework for analysis and research. London: Routledge; 1999.
[54] Graeber D. Toward an anthropological theory of value: the false coin of our own dreams. New York: Palgrave; 2001.
[55] Hitlin S, Piliavin JA. Values: reviving a dormant concept. Annu Rev Sociol 2004;30:359–93.
[56] Woodall T. Conceptualising "value for the customer": an attributional, structural and dispositional analysis. Acad Mark Sci Rev 2003;2003:1–44.
[57] Kotler P. Marketing management: analysis, planning, implementation, and control. 8th ed. London: Prentice-Hall International; 1994.
[58] Modi V, McDade S, Lallement D, Saghir J. Energy services for the Millennium Development Goals. New York: UN; 2005.
[59] Mayer-Tasch L. GTZ solar lamps (pico-PV) field test: consumer preferences and impacts ongoing GTZ solar lamps study. Kampala: GTZ; 2010.
[60] GIZ EnDev. What difference can a PicoPV system make? Eschborn, Germany: GTZ; 2010.
[61] ESDA. Proven in rural Africa: best practices in rural electrification using renewable energy in Africa. Nairobi; 2003.
[62] GIZ. A success story from the energy partnership: The PAMENU project in Northern Uganda. Eschborn, Germany: GIZ; 2011.
[63] Pine B, Gilmore J. Welcome to the experience economy. Harv Bus Rev 1998:97–105.
[64] Wagner J. Aesthetic value: beauty in art and fashion. 1st ed. London: Routledge; 1999.
[65] Mills E. The specter of fuel-based lighting. Science (Washington) 2005;308:1263–4.
[66] Lighting Africa. The off-grid lighting market in Sub-Saharan Africa: market research synthesis report. Washington DC; 2011.
[67] Baudrillard J. Consumer society: myths and structures. London: SAGE; 1998.
[68] Matinga MN, Annegarn HJ. Paradoxical impacts of electricity on life in a rural South African village. Energy Policy 2013;58:295–302.
[69] Veblen T, Mills C. The theory of the leisure class: an economic study of institution. Delhi: Aakar Books; 2005.
[70] Ger G, Belk R. I'd like to buy the world a coke consumptionscapes of the less affluent world. J Consum Policy 1996;19:271–304.
[71] DESA. World Urbanization Prospects the 2011 Revision. New York; 2012.
[72] Sheth JN, Newman BI, Gross BL. Why we buy what we buy: a theory of consumption values. J Bus Res 1991;22:159–70.
[73] Smith J, Colgate M. Customer value creation: a practical framework. J Mark Theory Pract 2007;15:7–23.
[74] Drucker P. Managing in the next society. Oxford: Butterworth-Heinemann; 2002.
[75] Broekhuizen T. Understanding channel purchase intentions: measuring online and offline shopping value perceptions. Ridderkerk, The Netherlands: Rijksuniversiteit Groningen; 2006.
[76] OED. Utility. Oxford English Dictionary; 2013.
[77] Lapierre J. Customer-perceived value in industrial contexts. J Bus Ind Mark 2000:122–40.
[78] Palit D, Chaurey A. Off-grid rural electrification experiences from South Asia: status and best practices. Energy Sustain Dev 2011;15:266–76.
[79] Shrimali G, Rohra S. India's solar mission: a review. Renew Sustain Energy Rev 2012;16:6317–32.
[80] Sovacool BK. Expanding renewable energy access with pro-poor public private partnerships in the developing world. Energy Strateg Rev 2013; 1:181–92.

[81] Reiche K, Covarrubias A, Martinot E. Expanding electricity access to remote areas: off-grid rural electrification in developing countries. Fuel 2000:52–60.
[82] Omwansa T, Sullivan N. Prepaid & pay-as-you-go models for asset financing analysis of mobile-money business models for kickstart (irrigation pumps) and M-KOPA (solar panels) in Kenya; 2013. p. 1–8.
[83] Schroeter BA. Experiences with PPP – Public Private Partnership – in rural Electrification. Lao PDR: UNEP.
[84] Madubansi M, Shackleton CM. Changing energy profiles and consumption patterns following electrification in five rural villages, South Africa. Energy Policy 2006;34:4081–92.
[85] Brüderle A, Attigah B, Bodenbender M. Productive use of energy – PRODUSE a manual for electrification practitioners. Eschborn, Germany: GTZ; 2011.
[86] Bensch G, Kluve J, Peters J. Impacts of rural electrification in Rwanda. J Dev Eff 2011:37–41.
[87] Bernard T. Impact analysis of rural electrification projects in Sub-Saharan Africa. World Bank Res Obs 2010;27:33–51.
[88] Yadoo A. Delivery models for decentralised rural electrification case studies in Nepal, Peru and Kenya. London; 2012.
[89] Howe C, Lawrence J, Patel H. SolarAid: revolutionizing the way to make energy affordable for everyone. Hult Int Bus Sch Publ 2012;17:1–17.
[90] Rahman MM, Paatero JV, Poudyal A, Lahdelma R. Driving and hindering factors for rural electrification in developing countries: lessons from Bangladesh. Energy Policy 2013;61:840–51.
[91] IMF. Uganda: poverty reduction strategy paper. Washington DC; 2010.
[92] Collings S. Phone Charging Micro-businesses in Tanzania and Uganda. London: GVEP; 2011.
[93] Bazilian Jr M, Pielke R. Making Energy Access Meaningful. Sci Technol 2013;2013:74–9.
[94] Barua R, Kroon B, van der, Renner T, Retamal C, Tigabu A, van Beukering P. Sustainability assessment framework energising development projects. Amsterdam: IVM Institute for Environmental Studies; 2011.
[95] World Bank. IDA – Providing Electricity in Rural Lao PDR; 2007.
[96] Müggenburg H, Tillmans A, Schweizer-Ries P, Raabe T, Adelmann P. Social acceptance of PicoPV systems as a means of rural electrification—a socio-technical case study in Ethiopia. Energy Sustain Dev 2012;16:90–7.
[97] Pigaht M, Schragl PPSP. Hydro I – Rwanda. Energypedia 2008 ⟨https://energypedia.info/images/8/80/Psp_hydro_rwanda_baseline_report_-_rwi2009.pdf⟩.
[98] Ulaga W. Capturing value creation in business relationships: a customer perspective. Ind Mark Manag 2003;32:677–93.
[99] Leelaratne M. Some recent technological advancements in the efficient use of biomass as an energy source in Sri Lanka. Sri Lanka: National Engineering Research and Development Centre of Sri Lanka; 2003.
[100] Pursnani P. Helpline: expert response by Pradeep Pursnani. The Boiling Point; 2010. p. 34–5.
[101] Maslow A. A theory of human motivation. Psychol Rev 1943;50:370–96.
[102] Cox CSJ. Assessment of emerging innovative energy efficient technologies as part of the energy efficiency innovation review. Harwell: DEFRA; 2005.
[103] IFC. From gap to opportunity: business models for scaling up energy access. Washington DC, USA; 2012.
[104] Chaurey A, Kandpal TC. Assessment and evaluation of PV based decentralized rural electrification: an overview. Renew Sustain Energy Rev 2010;14: 2266–78.
[105] Lahimer AA, Alghoul MA, Yousif F, Razykov TM, Amin N, Sopian K. Research and development aspects on decentralized electrification options for rural household. Renew Sustain Energy Rev 2013;24:314–24.
[106] Abdullah S, Jeanty P. Demand for electricity connection in rural areas: the case of Kenya. Bath Econ Res Pap 2009;26:1–44.
[107] Yadoo A, Cruickshank H. The role for low carbon electrification technologies in poverty reduction and climate change strategies: a focus on renewable energy mini-grids with case studies in Nepal, Peru and Kenya. Energy Policy 2012;42:591–602.
[108] IFC. Lighting Africa. Solar lighting for the base of the pyramid – overview of an emerging market; 2010.
[109] Pereira MG, Sena JA, Freitas MAV, Da Silva NF. Evaluation of the impact of access to electricity: a comparative analysis of South Africa, China, India and Brazil. Renew Sustain Energy Rev 2011;15:1427–41.
[110] Solomon M. The value of status and the status of value. In: Holbrook MB, editor. Consumer Value – A Framework for Analysis. London: Routledge; 1999. p. 63–84.
[111] Norris P, Inglehart R. God, guns and gays. Public Policy Res 2006;12:224–33.
[112] Shahid R, Zuettel I. Global index of religiosity and atheism; 2012.
[113] Dahl AL. Achievements and gaps in indicators for sustainability. Ecol Indic 2012;17:14–9.
[114] Ratner BD. "Sustainability" as a dialogue of values: challenges to the sociology of development. Sociol Inq 2004;74:50–69.
[115] The Inspection Panel. The inspection panel annual report fiscal year 2009. UN; 2009.
[116] OED. Subjectivism. Oxford English Dictionary; 2013.
[117] Aker J, Mbiti I. Mobile phones and economic development in Africa. Center for Global Development, Working Paper; 2010.
[118] Brown-out. Oxford English Dictionary.
[119] Gali J. Keeping up with the Joneses: consumption externalities, portfolio choice, and asset prices. J Money, Credit Bank 1994;26:1–8.